UNIVERSITY COLLEGE LONDON

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EXAMINATION FOR INTERNAL STUDENTS

For the following qualifications :-

B.Eng. *M.Eng.*

Chemical Eng E879: Biochemical Reaction Engineering

COURSE CODE	:	**CENGE879**
UNIT VALUE	:	**0.50**
DATE	:	**03-MAY-02**
TIME	:	**10.00**
TIME ALLOWED	:	**3 hours**

02-C0197-3-60

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UNIVERSITY OF LONDON

Chemical Engineering

E879

Answer ***FOUR QUESTIONS.***
ALL *questions carry a total of* ***25 MARKS*** *each, distributed as shown* [ ]

1. Outline the logic, using quantitative and qualitative arguments, for selection of a plug-flow packed bed, batch stirred tank, fed-batch stirred tank or continuous stirred tank reactor in the following four cases. The enzyme and reaction properties for these four separate cases are as follows:

a) Reaction requires pH control and high conversion. Enzyme follows Michaelis-Menten kinetics and is costly. [5]

b) Reaction requires pH control and high conversion. Enzyme follows Michaelis-Menten kinetics and is cheap. [5]

c) Reaction requires high conversion. Enzyme exhibits product inhibition and is costly. [5]

d) Reaction requires high conversion. Enzyme exhibits substrate inhibition and is costly. [10]

2. A biocatalytic reactor is fed reactant such that the concentration of this reactant is maintained constant. The reaction takes place at 200 U/gdcw. Assuming two downstream operations from the reactor with losses averaging 20% in each operation, how large is the fermentation volume required to supply sufficient intact resting cell biocatalyst to produce 700 kg of product in 10 hours of operation? Assume the cells maintain their activity over the entire 10 hours, MW of product is 100 and fermentation produces 30 gdcw/L with 10% losses upon transfer from the fermenter to the reactor. [15]

Plot the fermentation volume required as a function of the cell concentration produced in the fermenter. [10]

3. Outline the differences between the use of whole cells and isolated enzyme catalysts for biocatalysis. Draw typical flowsheets for each process and list the advantages and disadvantages of each catalyst type. Which reactions are most suited to each type of catalyst? [25]

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4. This question concerns the use of immobilised enzymes as biological catalysts.

a) List the main features (advantages and disadvantages) of using an immobilised rather than a freely suspended enzyme as a biological catalyst. [5]

b) Qualitatively describe the diffusional limitations possible with such systems. [5]

c) Define the internal effectiveness factor (η) and Thiele modulus (ϕ) for an enzyme immobilised in a porous particle. [5]

d) Plot η as a function of ϕ, indicating typical values. In which region of the plot would it be best to operate for effective use of an enzyme? What might practically prevent operation in this region? [10]

5. The reversible, elementary, liquid phase reaction $A \Leftrightarrow B$ takes place in a batch reactor. The reaction rate constants for the forward reaction and the reverse reactions are

$A \rightarrow B$ $k_1 = \exp(18.42 - 5000/T)\ \text{hr}^{-1}$ (where T is in Kelvin)
$B \rightarrow A$ $k_2 = \exp(36.84 - 10000/T)\ \text{hr}^{-1}$

At what temperature should you operate the reactor to get maximum conversion of A when the reaction time is 1 hr ? [20]
What is the reason that this maximum of conversion versus temperature is observed? [5]
(Hint: the temperature is between 260 - 290 K).

6. A dilute aqueous solution of A reacts continuously and isothermally according to the reaction $A \rightarrow B$. The reaction is first order with respect to A with reaction rate constant $k = 0.159\ \text{min}^{-1}$. The volumetric flowrate of the feed is $0.5 \cdot 10^{-3}\ \text{m}^3/\text{min}$ and the feed concentration of A is $0.15\ \text{kmol/m}^3$. There are two $2.5 \cdot 10^{-3}\ \text{m}^3$ and one $5 \cdot 10^{-3}\ \text{m}^3$ reaction vessels available with excellent agitation devices. Calculate the steady state conversion in each of the following cases:

a) The $5 \cdot 10^{-3}\ \text{m}^3$ vessel is used as a continuous flow reactor. [6]

b) The two $2.5 \cdot 10^{-3}\ \text{m}^3$ vessels are used as continuous flow reactors in series. [7]

c) The two $2.5 \cdot 10^{-3}\ \text{m}^3$ vessels are operated as continuous flow reactors in parallel, i.e. half of the feed is sent to each reactor and then the exit stream from each one are joined to form the final product. [6]

d) What is the conversion of an ideal plug flow reactor with volume $5 \cdot 10^{-3}\ \text{m}^3$? [6]

END OF PAPER